Module 2

Water and Climate Related Disasters

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Module 2: Water and Climate-Related Disasters

Floods, Cyclones-Tornadoes and Hurricanes, Hailstorm, Cloud Burst, Heat Wave and Cold Wave, Snow Avalanches, Droughts, Famine, Sea Erosion, Thunder and Lighting – Definition, Cause, Types, Safety Precautions


FLOODS


Mumbai


Uttarakhand, 2013


Cloudburst – Flash floods - Sikkim, 2023

Floods

An overflow of water onto normally dry land. The inundation of a normally dry area is caused by rising water in an existing waterway, such as a river, stream, or drainage ditch—ponding water at or near the point where the rain fell. Flooding is a longer-term event than flash flooding: it may last days or weeks.

Where can it occur?

- Coastal flood
- Riverine flood
- Flash flood

80%

Annual total rainfall South-west (SW) monsoon

Convective activities in the pre-monsoon period (March-June) include local storms/thunderstorms, cyclones, and post-monsoon cyclones (October-mid December).

Winter rains/snowfall over the northern part of India caused by western disturbances and the northeast (NE) monsoon in Tamil Nadu and the adjoining region also contribute to the total rainfall.

20%

Causes of floods

Flood dimensions

- Inundation due to spills over the banks,

- Drainage congestion due to poor drainage characteristics and

- Erosion due to changes in water courses.

The North-west River Region

River: Indus, Sutlej, Beas, Ravi, Chenab and Jhelum.

States: Jammu and Kashmir, Punjab and parts of Himachal Pradesh, Haryana, and Rajasthan.

The Central India and Deccan Region

Rivers: Narmada, Tapi, Mahanadi, Godavari, Krishna, and Cauvery.

States: Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Orissa, Maharashtra, Gujarat and parts of Madhya Pradesh

Regions in the Country Prone to Floods

The Brahmaputra River Region

Rivers: Brahmaputra and Barak and their tributaries

States: Assam, Arunachal Pradesh, Meghalaya, Mizoram, Manipur, Tripura, Nagaland, Sikkim and the northern parts of West Bengal

The Ganga River Region

Rivers: Yamuna, Sone, Ghaghra, Raphti, Gandak, Burhi Gandak, Bagmati, Kamla

Balan, Adhwara group of rivers, Kosi and the Mahananda.

States: Uttarakhand, Uttar Pradesh, Jharkhand, Bihar, south and central parts of West Bengal, Punjab, parts of Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh and Delhi.

Flood mitigation measures

Natural hazards cannot be prevented but damage and disruption due to natural hazards can be minimized by proper disaster management and planning. Mitigation measures are an important part of disaster management. mainly focuses on eliminating or reducing the risk from the hazards. Mitigation measures can be classified into:

Structural measures are defined as any physical construction, i.e., natural or artificial to decrease or eliminate the losses due to disasters. It is the implementation of engineering methods to build hazard-resistant structures to protect from hazards.

Non-structural measures are defined as measures that include policies and laws, plans and regulations, building codes, land use planning, laws and their enforcement, public awareness, training and education, warning systems, financial measures, and good management practices. These are useful to minimize the risk and impact of the hazards. Non-structural measures do not include physical construction.

The structural and non-structural measures used to safeguard against floods are discussed below:

Structural measures

- Reservoirs, Dams, and other Water Storage
- Embankments
- Channel Improvements
- Drainage Improvement
- Diversion of Flood Water/ Interlinking of Rivers
- Catchments Area Treatment/Watershed Management
- Sea Walls
- Coastal Protection Works
- Anti-Erosion Works

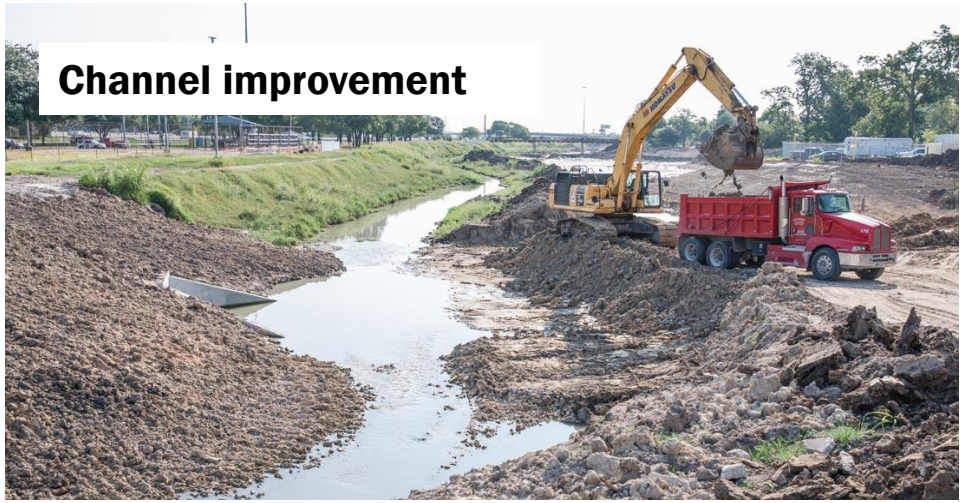
Non-structural measures

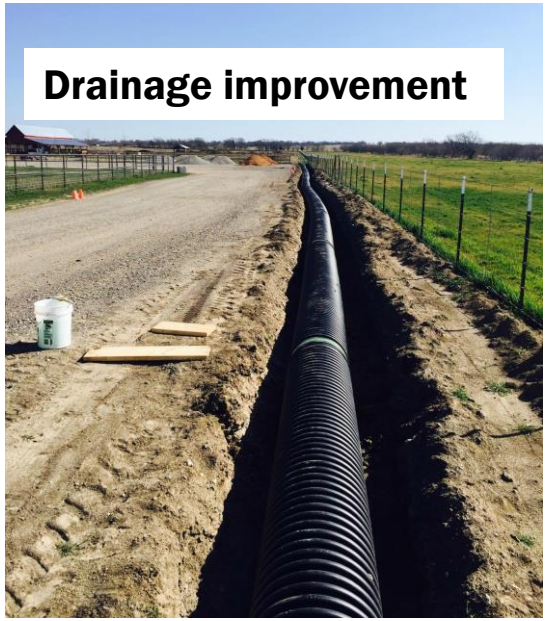
Non-structural measures are important aspects of reducing the impacts of Floods.

These also reduce the adverse effects on the environment. Non-structural measures to reduce or prevent the impacts of the flood are:

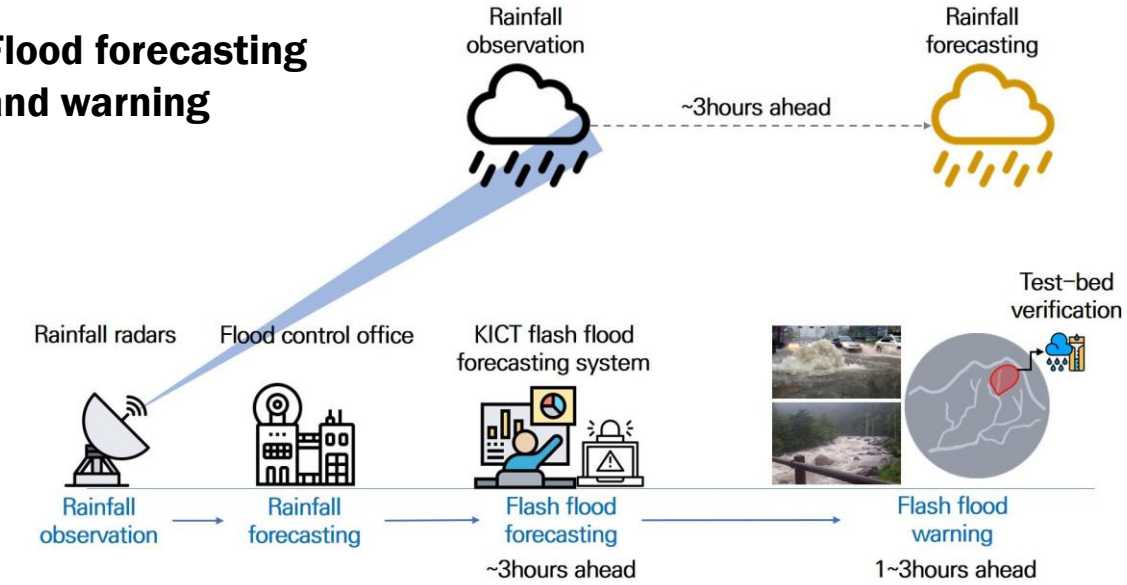
- Flood Plain Zoning
- Flood Forecasting and Warning
- Flood Proofing
- Flood Insurance
- Control of floodplain development
- Adherence to Coastal Zone Regulations

Structural measures

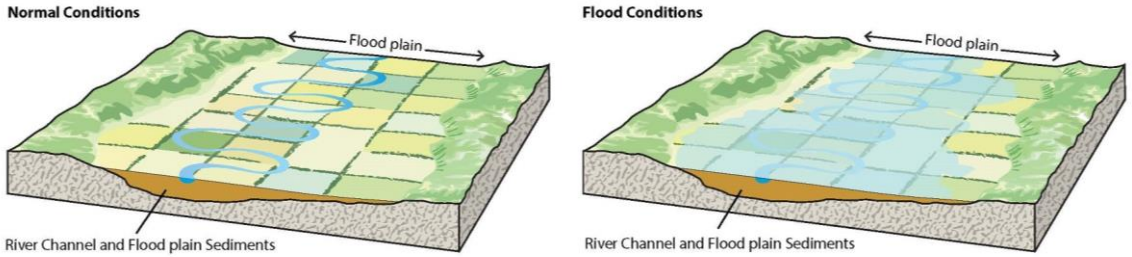




Flood forecasting and warning



What is a flood plain?



A floodplain (or floodplain) is a generally flat area of land next to a river or stream. It stretches from the banks of the river to the outer edges of the valley. A floodplain consists of two parts. The first is the main channel of the river itself, called the floodway.

Non-structural measures

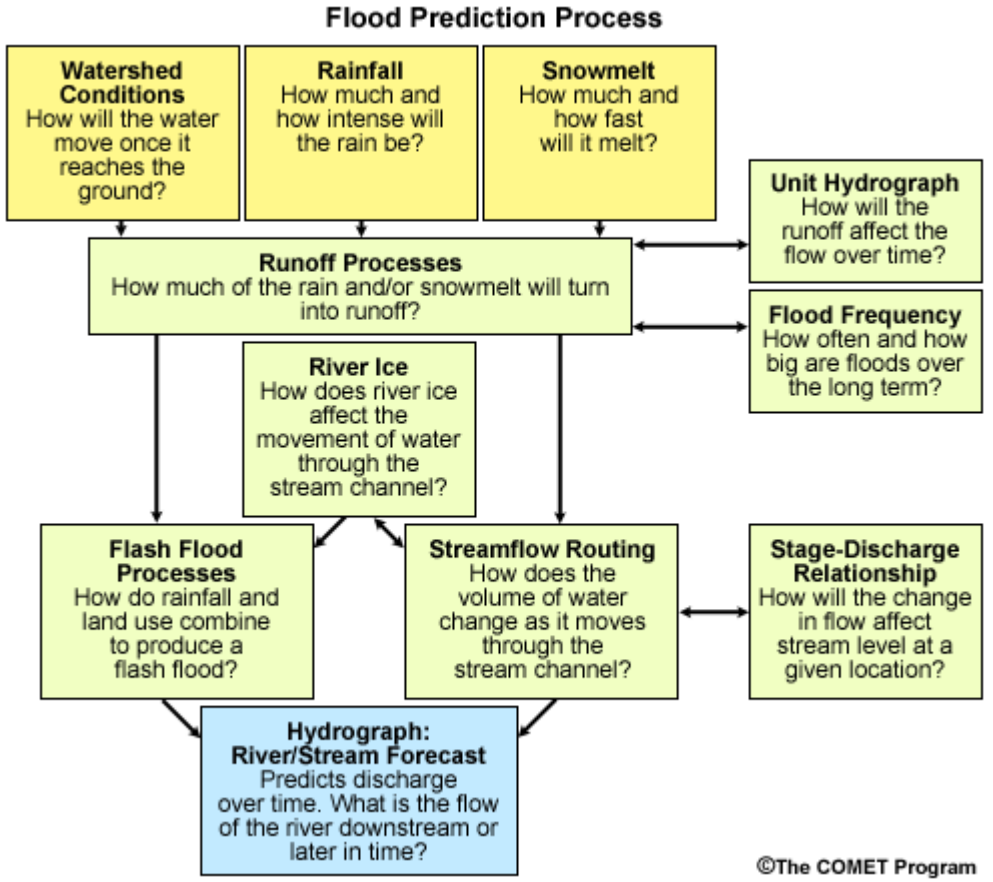
- Flood forecasting system

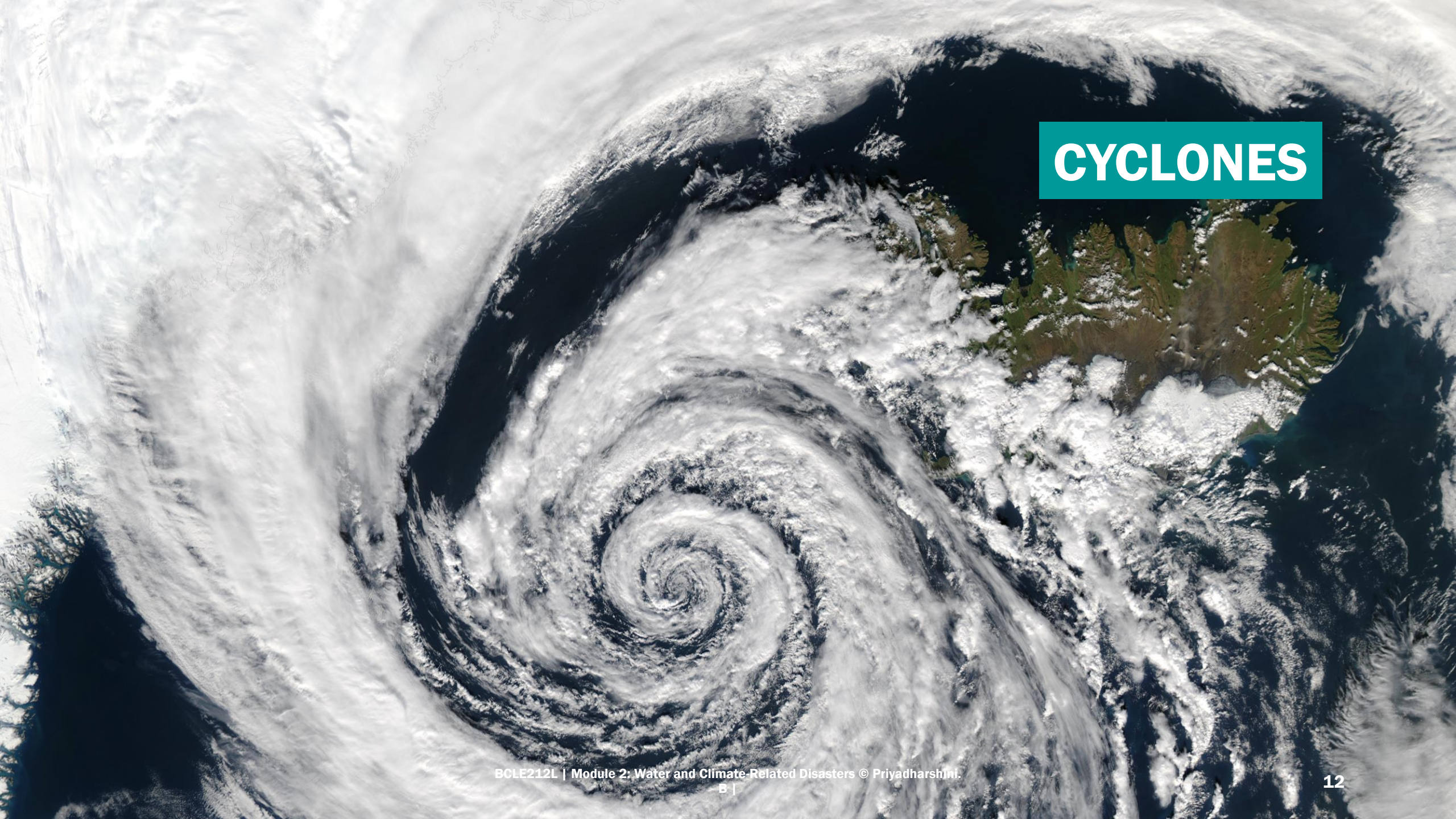
(Central Water Commission 1958)

184 Flood Forecasting Stations https://ffs.india-water.gov.in/

Flood forecasting can be defined as estimating and predicting the magnitude, timing, and duration of flooding based on known characteristics of a river basin, aiming to prevent damage to human life, properties, and the environment.

https://sites.research.google/floodforecasting/#alerts





CYCLONES

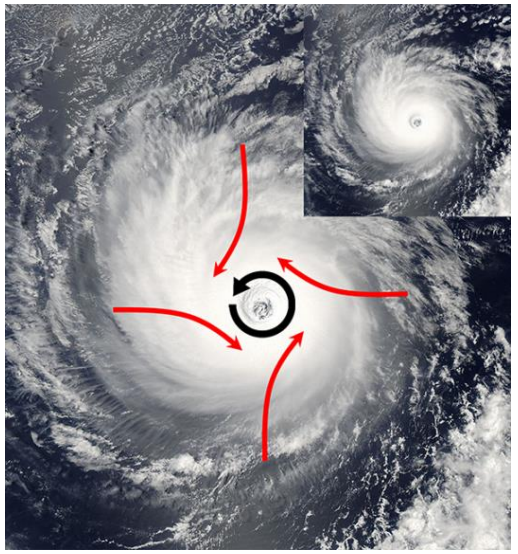
Cyclone

Greek word Cyclos means coils of a snake. It was coined by Henry Peddington because the tropical storms in the Bay of Bengal and the Arabian Sea appear like coiled serpents of the sea.

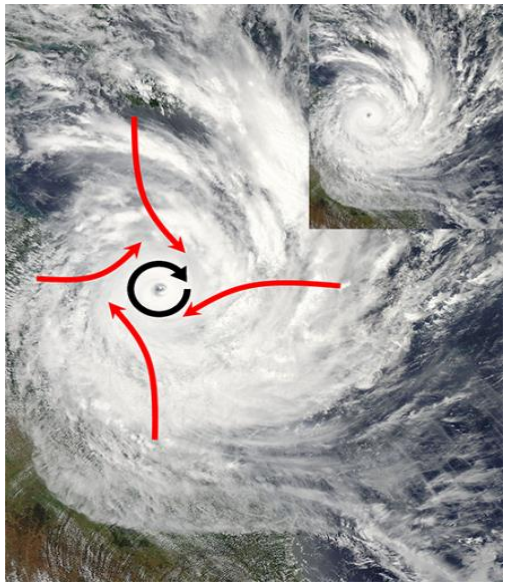
Cyclones are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation. Violent storms and bad weather usually accompany cyclones.

The air circulates inward in an anticlockwise direction in the Northern hemisphere and clockwise in the Southern hemisphere.

Cyclones are classified as: (i) extratropical cyclones (also called temperate cyclones); and (ii) tropical cyclones.



Northern hemisphere



Southern hemisphere

Indian Meteorological Department (IMD) classifies the low-pressure systems in the Bay of Bengal and the Arabian Sea based on capacity to damage, which the WMO adopts.

Type of Disturbances	Wind Speed in Km/h	Wind Speed in Knots (1 knot - 1.85 km per hour)
Low Pressure	Less than 31	Less than 17
Depression	31-49	17-27
Deep Depression	49-61	27-33
Cyclonic Storm	61-88	33-47
Severe Cyclonic Storm	88-117	47-63
Super Cyclone	More than 221	More than 120

In India, cyclones are classified by:

- Strength of associated winds,
- Storm surges
- Exceptional rainfall occurrences.

Cyclone Category	Wind Speed in Km/h	Damage Capacity
01	120-150	Minimal
02	150-180	Moderate
03	180-210	Extensive
04	210-250	Extreme
05	250 and above	Catastrophic

The very high specific humidity condenses into exceptionally large raindrops and giant cumulus clouds, resulting in high precipitation rates.

When a cyclone makes landfall, rain rapidly saturates the catchment areas, and the rapid runoff may extensively flood the usual water sources or create new ones.

Storm surges (tidal waves) are rising sea levels above the predicted astronomical tide. Major factors include:

A fall in the atmospheric pressure over the sea surface

- Influence of the seabed
- Effect of the wind
- A funneling effect
- The angle and speed at which the storm approaches the coast
- The tides

How are Cyclones formed?

The development cycle of tropical cyclones may be divided into three stages:

1. Formation and Initial Development Stage

The formation and initial development of a cyclonic storm depends upon various conditions. These are:

- A warm sea (a temperature in excess of 26 degrees Celsius to a depth of 60 m) with the abundant and turbulent transfer of water vapor to the overlying atmosphere by evaporation.
- Atmospheric instability encourages the formation of massive vertical cumulus clouds due to convection with condensation of rising air above the ocean surface.

2. Mature Tropical Cyclones

When a tropical storm intensifies, the air rises in vigorous thunderstorms and tends to spread out horizontally at the tropopause level. Once air spreads out, a positive perturbation pressure at high levels is produced, accelerating the downward motion of air due to convection. With the inducement of subsidence, air warms up by compression, and a warm 'Eye' is generated. Generally, the 'Eye' of the storms has three basic shapes: (i) circular, (ii) concentric, and (iii) elliptical. The main physical feature of a mature tropical cyclone in the Indian Ocean is a concentric pattern of highly turbulent giant cumulus thundercloud bands.

3. Modification and Decay

A tropical cyclone begins to weaken in terms of its central low pressure, internal warmth, and extremely high speeds as soon as its source of warm, moist air begins to ebb or is abruptly cut off. This happens after its landfall or when it passes over cold waters. The weakening of a cyclone does not mean the danger to life and property is over.

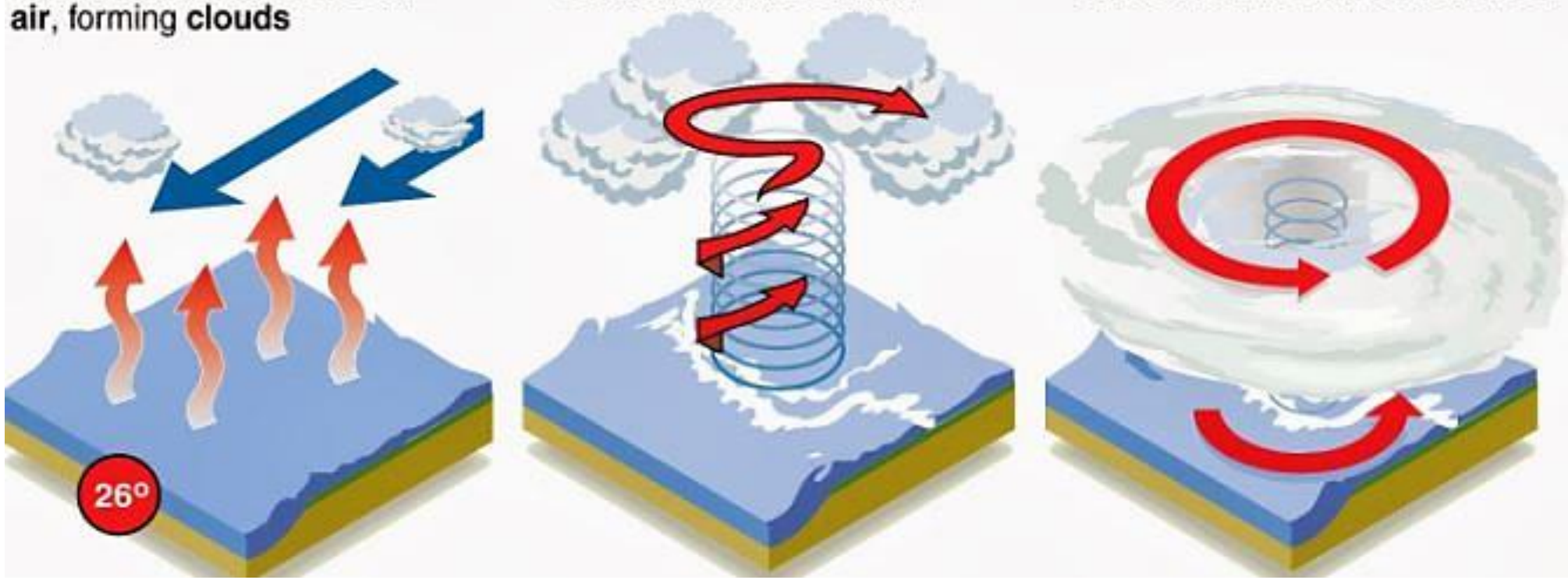
How tropical storms are formed

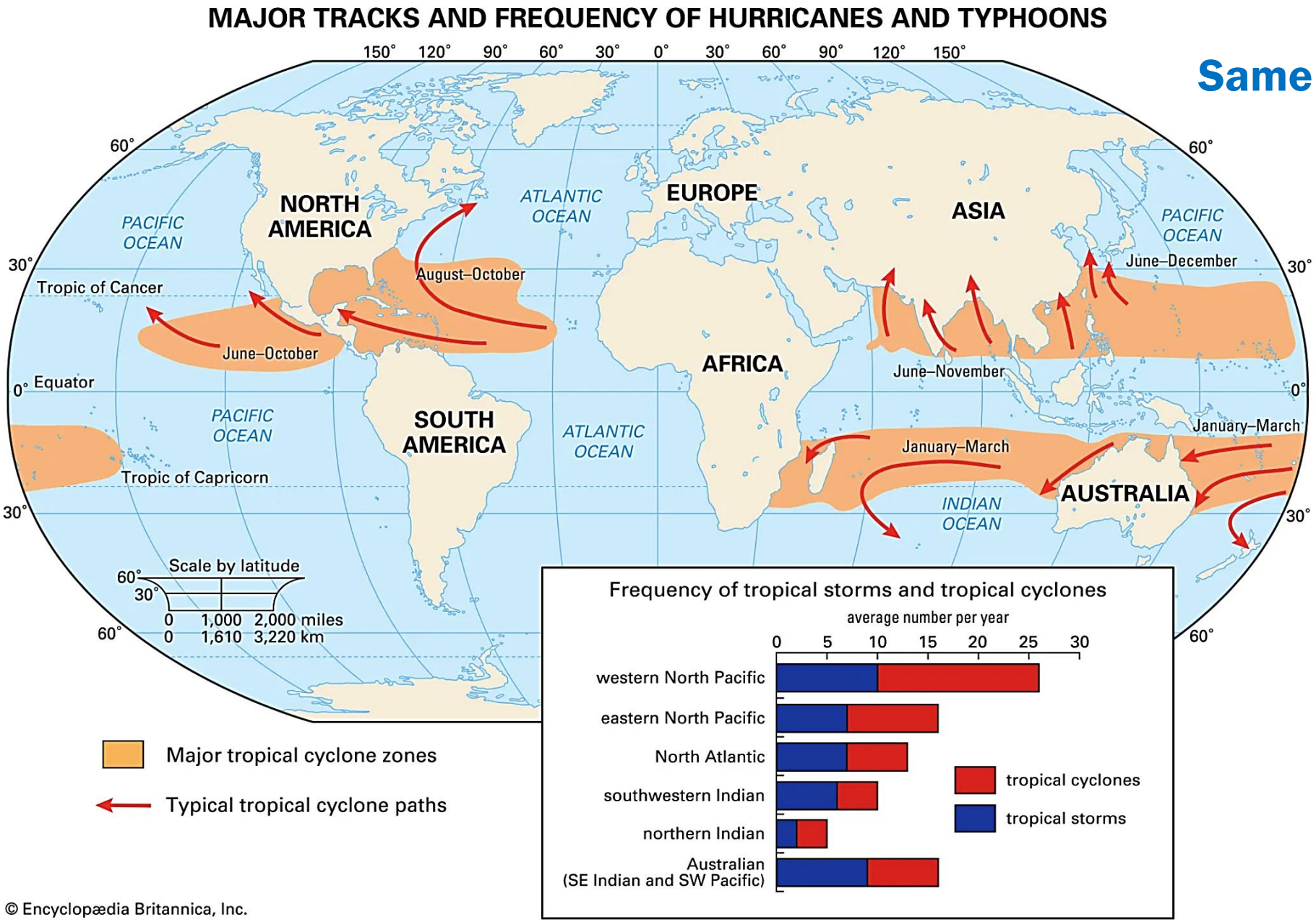
High humidity and ocean temperatures of over 26°C are major contributing factors

Water evaporates from the ocean surface and comes into contact with a **mass of cold air**, forming **clouds**

A **column of low pressure** develops at the centre. **Winds form** around the column

As pressure in the central column (the eye) weakens, the **speed of the wind around it increases**





Same name different places

- **Cyclone**
- **Hurricanes**
- **Typhoons**

Mitigation measures

The structural measures for mitigating the effects of cyclones include:

Cyclone shelter construction - The shelters can include buildings, places of worship, schools, community halls, etc.

Culverts, road links, and bridge construction - The conditions of roads, bridges, and culverts should be audited by the auth agencies for the smooth functioning of operations related to disaster management during cyclones. Roads, bridges, and culverts should be constructed for last-mile connectivity.

Drains, canals, and water tank construction - They are involved in the receipt, accommodation, and return of surge waters into the sea. Coastal canals may also be used as an alternative to roads for evacuating people from affected areas during a cyclone or flood.

Embankments for saline water - Construction and renovation of Saline Embankments are one of the important structural measures for the protection of coastal areas.

Towers for communication and networks for power transmission etc - It has been recommended that towers should be constructed for the 100-year return period of the cyclone's wind velocity. This should be based on the failure of communication and transmission towers in past cyclones.

Non-structural measures

Non-structural measures are used to reduce cyclonic risk through effective mitigation policies and strategies. These measures consist of

- **Early warning systems**
- **Systems for communication as well as dissemination**
- **Creating awareness and capacity building**
- **Developing shelter belts**
- **Coastal zone management**
- **Hazard mapping**

Thunderstorm, Hailstorm, Squall and Lightning

Thunderstorm

- A thunderstorm is said to have occurred if thunder is heard or lightning is seen. Usually, the thunder can be heard up to a distance of 40 km from the source of origin.
- Thunderstorms fall in the category of Meso-gamma weather systems with a spatial extent of around 2~20 km and a temporal scale of a few hours.
- Considering their intensity, the thunderstorms in India are categorized as follows:
  - Moderate thunderstorm: Loud peals of thunder with associated lightning flashes, moderate to heavy rain spells, and maximum wind speed of 29 to 74 kmph.
  - Severe thunderstorm: Continuous thunder and occasional hailstorm, and maximum wind speed exceeding 74 kmph.

Thunderstorm

Thunderstorms occur around the year in different parts of the country. However, their frequency and intensity are maximum during the summer months (March to June) as the most important factor for the occurrence of thunderstorms is the intense heating up of the atmosphere at the surface level.

Squall

A squall is defined as a sudden increase in wind speed of at least 29 kmph (16 knots) with the speed rising to 40 kmph (22 knots) or more and lasting for at least one minute. It is of two types:

Moderate squall: If the surface wind speed (in gusts) is up to 74 kmph.

Severe squall: If the surface wind speed (in gusts) is greater than 74 kmph.

The climatology of the spatial distribution of occurrence of a squall is almost the same as that of thunderstorms. The frequency and intensity of squall are maximum over eastern and northeastern States. Also, its frequency is maximum during the pre-monsoon season with an increasing trend from March to May in different parts of the country. However, there is a secondary maximum in the winter season over northwest India.

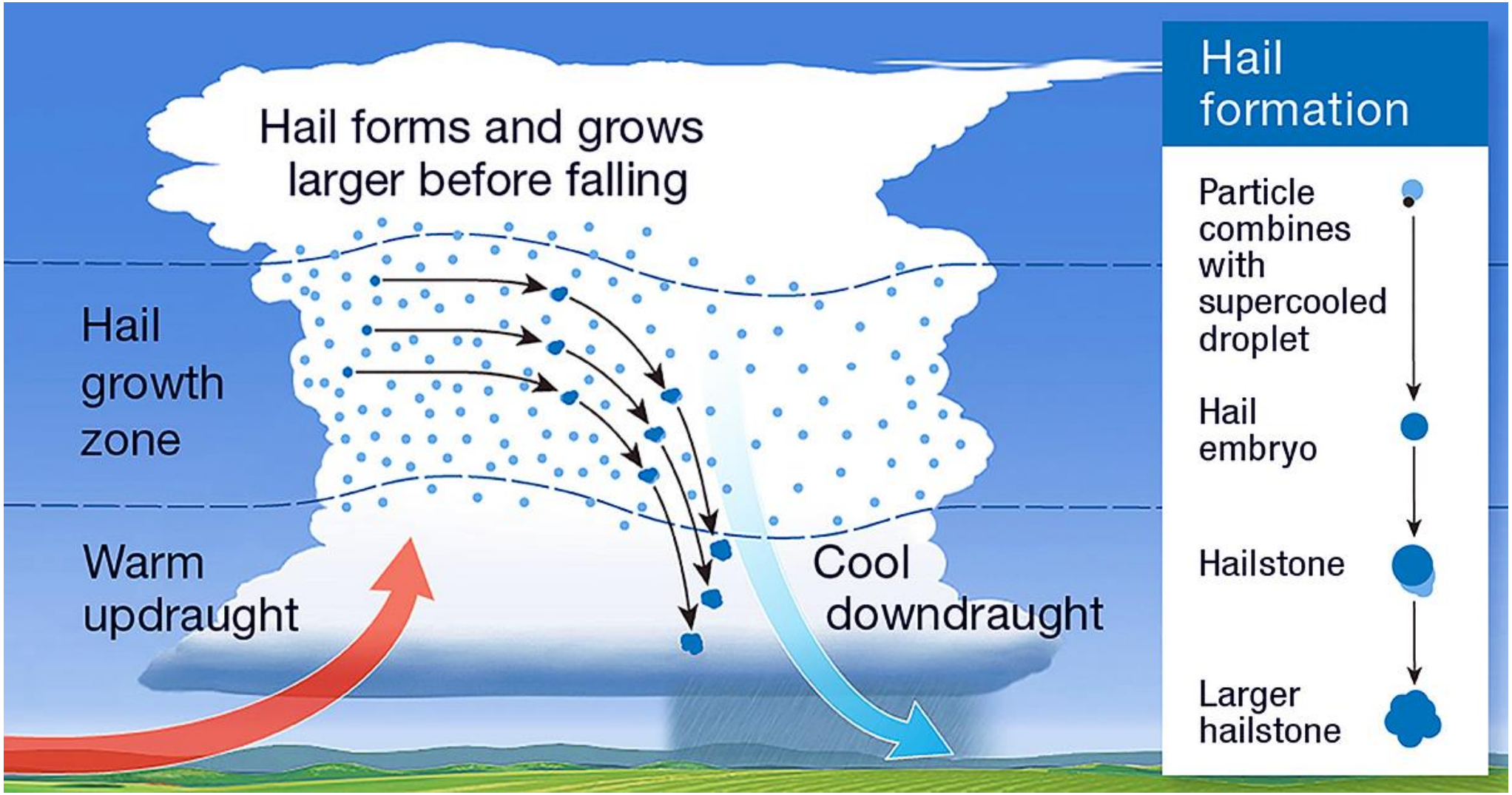
Hailstorm

- Meteorological event
- Hail is a form of precipitation consisting of solid ice that forms inside thunderstorm updrafts. Hail can damage aircraft, homes, and cars, and can be deadly to livestock and people.

Source: https://www.nssl.noaa.gov/education/svrwx101/hail/

- India, with about 29 hail days of moderate to severe intensity per year, is among those countries in the world that experience a very high frequency of hail.
- Hailstorms are mainly observed during the winter and pre-monsoon seasons with virtually no events after the onset of the southwest monsoon.
- It appears to be associated with a particular cell of convective cloud rather than a storm as a whole. Hail occurs in the mature stage if at all it occurs. Cells in which hails occur have updrafts of greater than average intensity, exceeding 15 meters per second. It is of three types:
- **Slight Hailstorm:** If it is sparsely distributed, usually small in size and often mixed with rain.
- **Moderate Hailstorm:** If it is abundant enough to whiten the ground.
- **Strong Hailstorm:** If it includes at least a proportion of large stones.

How does hail form?



Lightning

Lightning is a high-energy luminous electrical discharge accompanied by thunder. It is of three types:

1) Thundercloud or Intra-cloud lightning (IC)

2) Cloud-to-cloud or Inter-cloud lightning (CC)

3) Cloud-to-ground lightning (CG)

The third type of lightning takes a toll on lives and property, and therefore, is of more concern to us. However, inter-cloud and intra-cloud lightning are also dangerous as they may hit aircrafts. These are also the precursor to cloud-to-ground lightning. aircraft

Extreme weather

An extreme weather event is something that falls outside the realm of normal weather patterns. It can range from a flood to a drought to a hurricane to a hailstorm.

Severe weather

Severe weather is any dangerous meteorological phenomenon with the potential to cause damage, serious social disruption, or loss of human life.

Types of severe weather phenomena vary depending on the latitude, altitude, topography, and atmospheric conditions.

High winds, hail, excessive precipitation, and wildfires are forms and effects of severe weather, as are thunderstorms, downbursts, tornadoes, waterspouts, tropical cyclones, and extratropical cyclones.

Regional and seasonal severe weather phenomena include blizzards (snowstorms), ice storms, and duststorms.

Tornado

A tornado is a narrow, violently rotating air column extending from a thunderstorm to the ground.

Because wind is invisible, it is hard to see a tornado unless it forms a condensation funnel of water droplets, dust, and debris.

Tornadoes can be among the most violent phenomena of all atmospheric storms we experience.

Tornadoes occur in many parts of the world, including Australia, Europe, Africa, Asia, and South America. Even New Zealand reports about 20 tornadoes each year. Two of the highest concentrations of tornadoes outside the U.S. are Argentina and Bangladesh.

Droughts

Drought is a prolonged dry period in the natural climate cycle that can occur worldwide. It is a **slow-onset disaster** characterized by the lack of precipitation, resulting in a water shortage. Drought can severely impact health, agriculture, economies, energy, and the environment.

Drought may have acute and chronic health effects:

- Malnutrition due to the decreased availability of food;
- Increased risk of communicable diseases due to acute malnutrition, inadequate or unsafe water for consumption and sanitation, and increased crowding among displaced populations;
- Psycho-social stress and mental health disorders;
- Overall increase of population displacement; and
- Disruption of local health services due to a lack of water supplies and/or health care workers being forced to leave local areas.

Droughts

Source: https://www.who.int/health-topics/drought#tab=tab_2






Classification of drought

Drought results from long-continued dry weather and/or insufficient rain, which causes loss of soil moisture, depletion of underground water supply, and reduction of stream flow.

The National Commission on Agriculture in India defines three types of droughts:

1. **Meteorological drought** is when there is a significant decrease in average precipitation over an area (i.e., > 10 %).
2. **Hydrological drought** results from prolonged meteorological drought manifested in surface and subsurface water resource depletion. It must be noted that hydrological drought could occur even when the rainfall is average if there has been a substantial reduction in surface water holding capacity.
3. **Agricultural drought** is when soil moisture and rainfall are inadequate to support healthy crop growth.

The impact, response, and interventions would vary depending on at what point in a crop calendar there is a water or soil moisture deficit.

(a) Early season: Delayed rainfall (delayed onset of monsoon), prolonged dry spells after onset;

(b) Mid-season: Inadequate soil moisture between two rain events; and

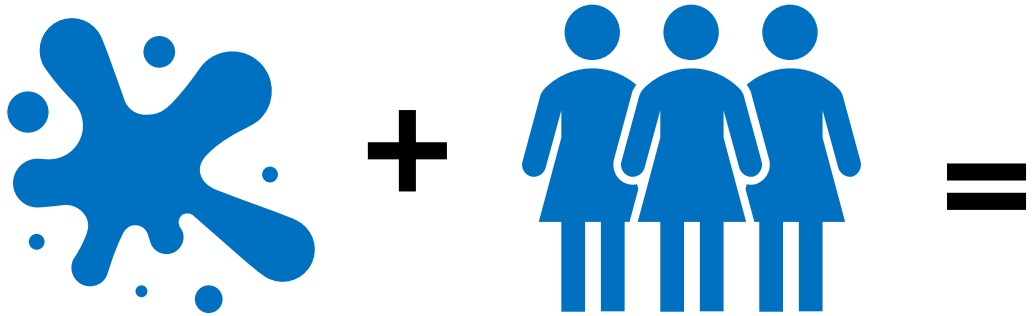
(c) Late season: Early cessation of rains or insufficient rains.

Climate Variability – short-term changes

1. Drought week – ½ of its normal amount in a week
2. An agricultural drought – 4 consecutive drought weeks
3. A seasonal drought – deficit than the normal seasonal average
4. A drought year, when annual rainfall is deficient by 20 % of normal or more
5. Severe drought year; when annual rainfall is deficient by 25-40% of normal or more

Drought monitoring is an essential component of drought risk management. It is usually carried out using drought indices/indicators that are continuous functions of rainfall and other hydrometeorological variables.

Drought risk



Water shortage + Exposure of the communities =

A drought atlas for India is being prepared by the National Atlas and Thematic Mapping Organization
https://geoportal.natmo.gov.in/dataset/drought-areas (NATMO)

Drought vulnerability

Vulnerability Analysis Using Multiple Criteria Variables

Meteorological – rainfall, temperature, etc

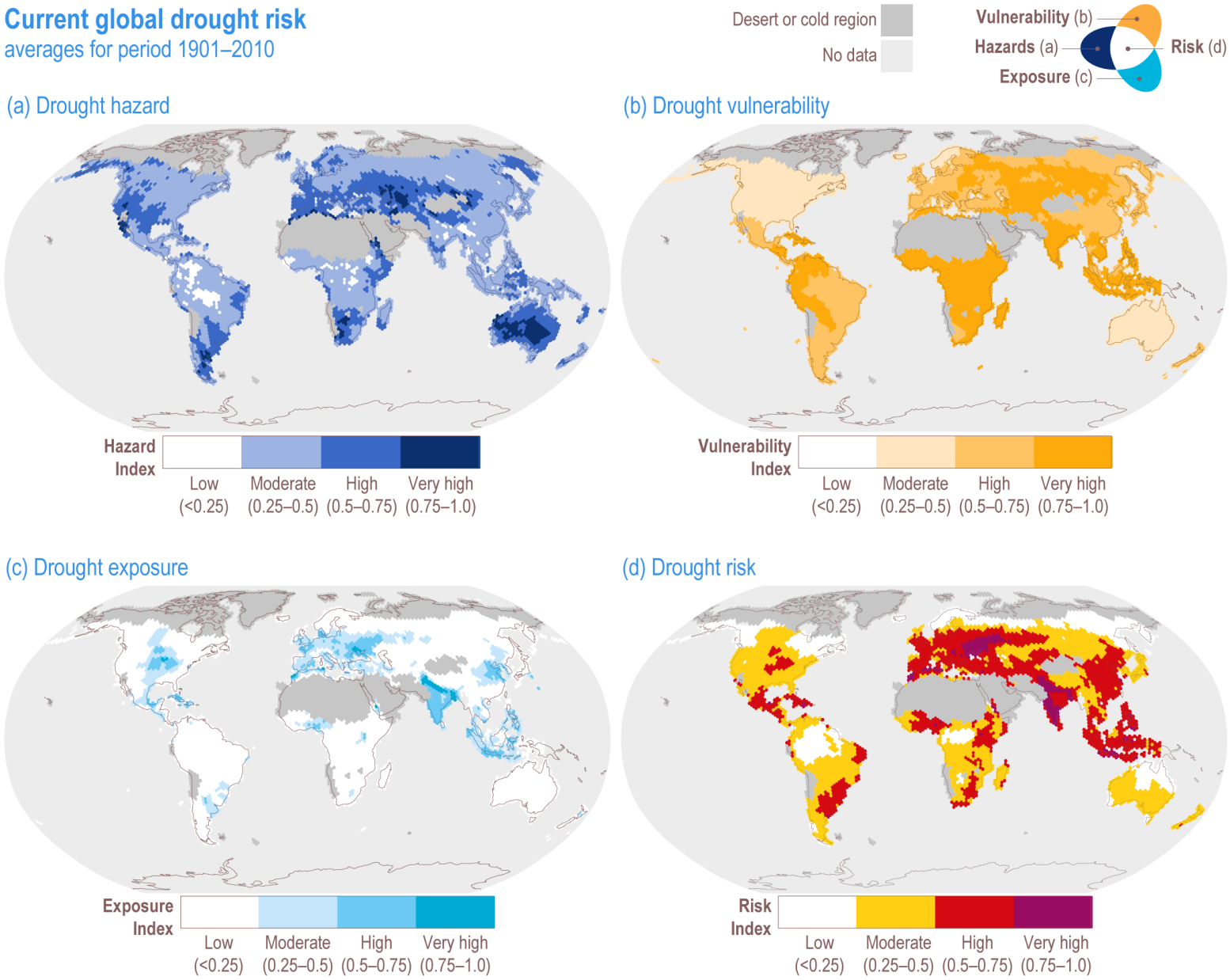
Soils - depth, type, available water content, etc

Surface water use - percent irrigated area, surface water supplies

Groundwater – groundwater availability/ utilization

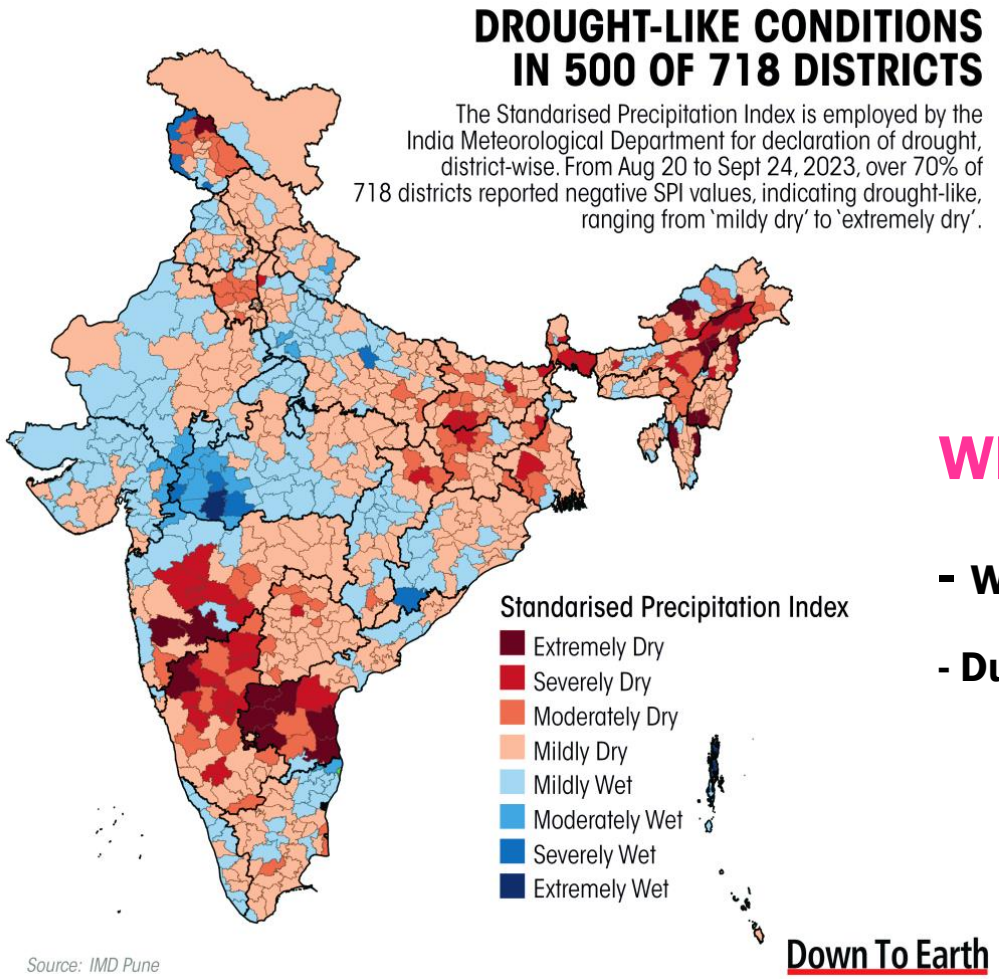
Crop–cropping pattern changes, geospatial land use, crop condition, anomalies of crop condition, etc.

Socio-economic – population of weaker sections, size class of farm holdings



Global drought risk

Adopted from IPCC AR6 WG1, Figure 4.9, Current global drought risk and its components.



What is your observation from the map beside?

- **Wildfire**

- **Dust (illness)**

Famine

A famine is an acute episode of extreme hunger that results in excess mortality due to starvation or hunger-induced diseases.

- Bengal Famine of 1943
- Chalisa Famine of 1783
- Great Bengal Famine of 1770
- Skull Famine of 1791
- Orissa Famine of 1866
- Deccan Famine of 1630
- Bihar Famine of 1873
- Agra Famine of 1837

Dimension

- Food consumption and livelihood change
- Nutritional status
- Mortality (due to inadequate food consumption)

Source: https://ourworldindata.org/famines
https://byjus.com/biology/famine/#:~:text=Some%20of%20the%20prime%20reasons,%2C%20crop%20failure%2C%20government%20policies.

Monitoring of Drought

Rainfall and other associated weather parameters

Crop health (based on satellite-derived NDVI and field reports

Available ground water (variation in groundwater table) and surface water resources

Migration and its impact on the community

Observational Network

For such monitoring, one would require a reasonably dense observational network.

1. Automatic weather station (25 km X 25km);
2. Automatic rain gauge (5 km X 5 km);
3. Ground water table observation (5 km X 5 km in hard rock region and 10 km X 10 km in alluvial plains);
4. Field report from block / mandal level; and
5. Satellite data of 50 m X 50 m resolution

National Remote Sensing Centre - 17 states of India

National Agricultural Drought Assessment and Monitoring System (NADAMS)

Multi-satellite Multi-date data

VI
Time composite

NDVI/NDWI anomaly assessment
1. Relative deviation
2. VCI
3. In-season change

Ground information

Irrigation (%)

Rainfall deviation

Sown area deviation

Agricultural drought situations

Drought warming (June, July, August)	Drought declaration (September, October)
Normal	Mild
Watch	Moderate
Alert	Severe

Additional information

Change in crop calendar

Lag between VI & Rainfall

Abnormal weather events (e.g., Floods)

Immediate Measures

With a view to ensuring timely declaration of drought

a. Rainfall deviations at taluka/block level;
b. Number and length of the dry spell at taluka/block level
c. Progression of crop area sown at district/taluka level
d. Satellite-derived indicators such as the Normalized Difference Vegetation Index (NDVI), Normalize Difference Water Index (NDWI), and interpreted maps/images provided by NRSC and ISRO
e. Groundwater availability map

The Drought Monitoring Cell (DMC) in the states will receive and collate the weather data from multiple sources across the state, like IMD, Irrigation Department, Department of Agriculture, Groundwater Department;

Data on water levels in reservoirs/ tanks, groundwater, etc., will be received weekly from the concerned departments;

The existing departments will do this work of collection and collation at the district level, and the information will be supplied to DDMA and SDMA;

The data from the sub-district level through the District and State level will be available online.

The DMC will prepare weekly status of weather and crop conditions on the following indicators.

Immediate measures continued

- Declaration of drought will be done in a timely manner, preferably in three phases (1) end of July, (2) end of September, and (3) end of November.
- Declaration in each phase will account for the beneficial effects of rainfall from the time of the previous declaration and change in the agricultural situation;
- Interim relief measures will commence from the middle of the season
- The final relief measures will be implemented after the final declaration at the end of the season;
- After the declaration of the Drought, the SDMA Secretariat will take steps to approach the Centre for financial and other assistance
- The DMC as a part of the State Disaster Management Authority, will work in close coordination with State.

Cloud burst

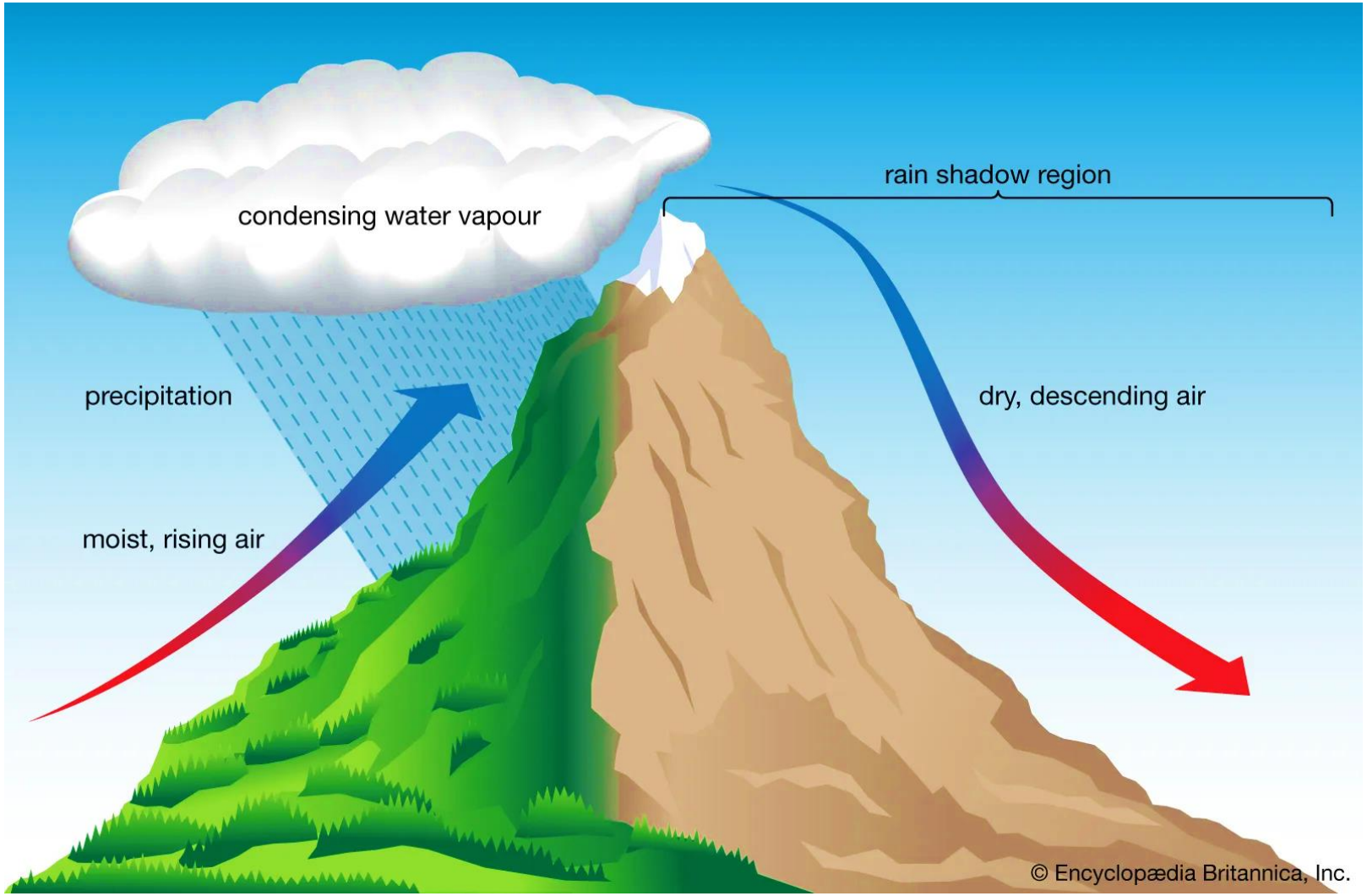
- When thunderstorms cause heavy rainfall in a very short span of time, water may exceed the carrying capacity of the rivers. This spills the water to nearby areas sometimes causing extensive damage and destruction.
- A flash flood is a due to a cloud burst

Orographic lifting and cloudburst

4. Lack of upward air prevents dissipation of moisture

5. Whole of the stored waterfalls at one time

3. Violent upward Flow of air prevents the condensing raindrops from falling to the ground



6. Steep slope causes flash floods

2. Rising air cools and condenses clouds develop

1. Moist air Encounters a mountain or hill and is forced to rise

Heat wave

- A Heat Wave is a period of abnormally high temperatures, more than the normal maximum temperature that occurs during the summer season in the North-Western parts of India.
- Heat Waves typically occur between March and June, and in some rare cases even extend till July.
- The peak month of the heat wave over India is May.

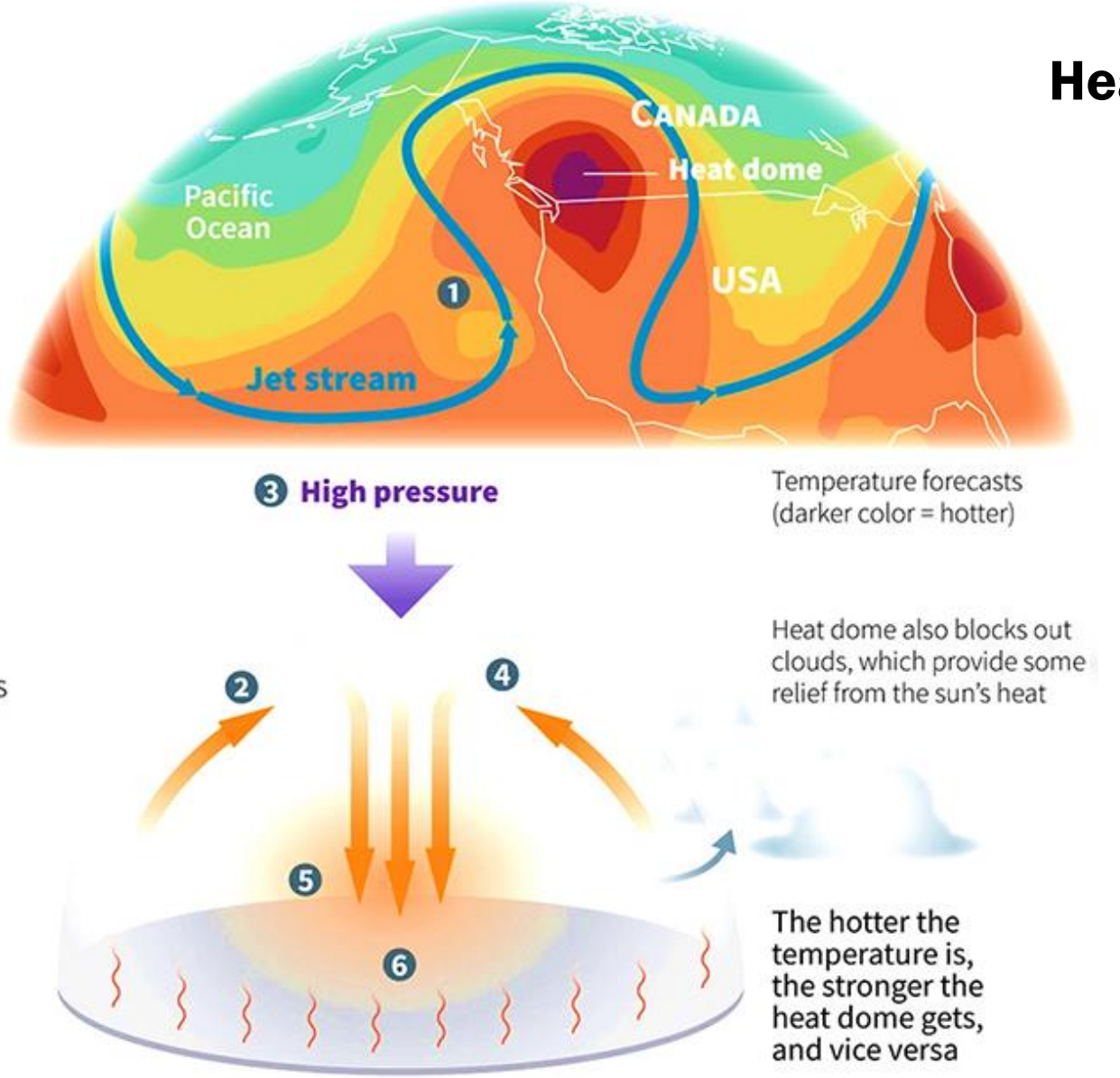
Source: https://internal.imd.gov.in/section/nhac/dynamic/FAQ_heat_wave.pdf

Heat Waves and Heat Dome

The ‘heat dome’

Occurs when the atmosphere traps hot ocean air like a lid or cap

1. In summer, the **jet stream** (which moves the air) shifts northward
2. **Hot** and stagnant **air expands** upwards
3. Strong and **high-pressure** atmospheric conditions combine with influences from La Nina act like a dome or cap
4. In a process known as **convection,** hot air attempts to escape but high pressure pushes it back down
5. Under the dome, the air sinks and **compresses,** releasing more heat
6. As winds move the hot air east, the jet stream traps the air where it sinks, resulting in **heat waves**



What is the criterion for declaring a heat wave?

The heat wave is considered if the maximum temperature of a station reaches at least 40°C or more for Plains and at least 30 C or more for Hilly regions.

a) Based on Departure from Normal

Heat Wave: Departure from normal is 4.5°C to 6.4°C

Severe Heat Wave: Departure from normal is >6.4°C

b) Based on Actual Maximum Temperature

Heat Wave: When actual maximum temperature ≥ 45°C

Severe Heat Wave: When actual maximum temperature ≥47°C

If the above criteria are met at least in 2 stations in a Meteorological sub-division for at least two consecutive days it is declared on the second day.

What is a criterion for describing Heat Wave for coastal stations?

- When the maximum temperature departure is 4.5°C or more from normal, Heat Wave may be described provided the actual maximum temperature is 37°C or more.

What is warm night?

It is considered only when the maximum temperature remains 400C or more.

It is defined based on departures or actual minimum temperatures as follows:

Warm night: minimum temperature departure is 4.5°C to 6.4°C

Very warm night: minimum temperature departure is >6.4°C

How India Meteorological Department (IMD) monitor the Heat wave?

- IMD has a big network of surface observatories covering the entire country to measure various metrological parameters like Temperature, Relative humidity, pressure, wind speed and direction, etc.
- Based on daily maximum temperature station data, climatology of maximum temperature is prepared for the period 1981-2010 to find out normal maximum temperature of the day for a particular station.
- Thereafter, IMD declared heat wave over the region as per its definition.

What is the temporal range of temperature forecast issued by IMD?

- IMD issues temperature forecast and warning in the following range:
- a) Short to medium range (lead time/validity of 1 to 5 days)
- b) Extended range (lead time/validity upto 4 weeks)
- c) Seasonal range (lead time/validity up to 3 months)

How IMD predicts the Heatwave?

IMD predicts heat waves based on synoptic analysis of various meteorological parameters and from the consensus guidance from various regional & global numerical prediction models like, WRF, GFS, GEFS, NCUM, UMEPS, UM Regional, etc. run in the Ministry of Earth Sciences (MoES) and other international models available under bilateral multi-institutional arrangement

How common man may get IMD Heat wave information?

- A common man may get heat wave information from, All India Weather Forecast Bulletin https://mausam.imd.gov.in/imd_latest/contents/all_india_forcast_bulletin.php and
- special heat wave guidance bulletins http://internal.imd.gov.in/pages/heatwave_mausam.php from 1 April to 30 June ever,yday.
- The heat wave information is shared with the concerned State Government Authority, Media and other stakeholders like the Indian Railway, Health departments, Power Sector etc. The general public is informed through Print and electronics Media.

What are favorable conditions for Heat wave?

a. Transportation / Prevalence of hot dry air over a region (There should be a region of warm dry air and an appropriate flow pattern for transporting hot air over the region).

b. Absence of moisture in the upper atmosphere (As the presence of moisture restricts the temperature rise).

c. The sky should be practically cloudless (To allow maximum insulation over

the region).

d. Large amplitude anti-cyclonic flow over the area.

Heat waves generally develop over Northwest India and spread gradually eastwards & and southwards but not westwards (since the prevailing winds during the season are westerly to northwesterly). But on some occasions, heat waves may also develop over any region in situ under favorable conditions.

How is heat discomfort determined?

It is determined by a combination of meteorological (temperature, Relative Humidity, wind, direct sunshine), social/cultural (clothing, occupation, accommodation) and physiological (health, fitness, age, level of acclimatization) factors.

What is the heat index (HI) ?

HI is the combination of air temperature and relative humidity, it measures of how hot it feels when relative humidity is factored in with the actual air temperature.

Colour Code	Alert	Warning	Impact	Suggested Actions
Green (No action)	Normal Day	Maximum temperatures are near normal	Comfortable temperature. No cautionary action required.	Nil
Yellow Alert (Be updated)	Heat Alert	Heat wave conditions at isolated pockets persists on 2 days	Moderate temperature. Heat is tolerable for general public but moderate health concern for vulnerable people e.g. infants, elderly, people with chronic diseases	(a) Avoid heat exposure. (b) Wear lightweight, light-coloured, loose, cotton clothes. (c) Cover your head: Use a cloth, hat or umbrella
Orange Alert (Be prepared)	Severe Heat Alert for the day	(i) Severe heat wave conditions persists for 2 days (ii) Through not severe, but heat wave persists for 4 days or more	High temperature. Increased likelihood of heat illness symptoms in people who are either exposed to sun for a prolonged period or doing heavy work. High health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.	(b) Avoid heat exposure– keep cool. Avoid dehydration. (b) Drink sufficient water- even if not thirsty. (c) Use ORS, homemade drinks like lassi, torani (rice water), lemon water, buttermilk, etc. to keep yourself hydrated
Red Alert (Take Action)	Extreme Heat Alert for the day	(i) Severe heat wave persists for more than 2 days. (ii) Total number of heat/severe heat wave days exceeding 6 days.	Very high likelihood of developing heat illness and heat stroke in all ages.	Extreme care needed for vulnerable people.

Heatwave index (HI)

Health Impacts of Heat Waves?

The health impacts of Heat Waves typically involve dehydration, heat cramps, heat exhaustion, and/or heat stroke. The signs and symptoms are as follows:

Heat Cramps: Edema (swelling) and Syncope (Fainting) are generally accompanied by fever below 39°C i.e. 102°F.

Heat Exhaustion: Fatigue, weakness, dizziness, headache, nausea, vomiting, muscle cramps and sweating.

Heat Stoke: Body temperatures of 40°C i.e. 104°F or more along with delirium, seizures, or coma. This is a potentially fatal condition.

General impacts of heat waves

Impact on Labor and Productivity: Heat exposure leads to a loss of 162 hours per year for laborers doing heavy work, impacting productivity.

About 50% of India's workforce is estimated to be exposed to heat during their working hours, including marginal farmers, construction workers, and street vendors.

Impact on the Agriculture Sector: Crop yields suffer when temperatures exceed the ideal range.

Farmers in Haryana, Punjab, and Uttar Pradesh have reported losses in their wheat crop in the past rabi season.

Livestock is also vulnerable to heat waves.

Food Insecurity: The concurrence of heat and drought events is causing crop production losses and tree mortality.

The risks to health and food production will be made more severe by the sudden food production losses exacerbated by heat-induced labor productivity losses.

These interacting impacts will increase food prices, reduce household incomes, and lead to malnutrition and climate-related deaths, especially in tropical regions.

Impact on Energy Demand: Average Daily peak demand rises due to increased heat

Cold waves

Cold waves

The cold wave conditions signify a certain amount of fall of temperature at a given place with respect to normal climatological value.

In India, cold wave (CW) conditions are generally experienced during the period from November to March.

However; the disaster data shows that the damages and casualties are associated with CWs during the months of December to March.

It has a severe impact on human health, varying from Cough and cold, bronchitis and respiratory diseases, Blood pressure issues, Skin problems, and even Bone, joint, and muscle pain due to lack of sunlight.

The health conditions, particularly of the poor people, are seriously affected, and in extreme cases even it cause casualty.

The criteria adopted by IMD to define Cold Wave is given below:

(a) A Cold Wave is considered when the minimum temperature of a station is

10°C or less for plains and 0°C or less for Hilly regions.

(i) Based on Departure

Cold Wave: Negative Departure from normal is 4.5°C to 6.4°C

Severe Cold Wave: Negative Departure from normal is more than 6.4°C

(ii) Based on Actual Minimum Temperature (For plain stations only)

Cold Wave: When the minimum temperature is ≤ 04°C

Severe Cold Wave: When the minimum temperature is ≤ 02°C

b) Cold Wave conditions for coastal stations

When the minimum temperature departure is -4.5°C or less over a station, a "Cold Wave" may be described if the minimum temperature is 150C or less.

References

Reference materials for each slide are quoted at the right end of the PowerPoint.